# AN ASSESSMENT OF CASINO CREEK: HABITAT AND AQUATIC INVERTEBRATE ASSEMBLAGES

**August 2000**

report prepared for

**The Montana Department of Environmental Quality**
**Helena, Montana**

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**October, 2001**

## INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in August 2000 from two sites on Casino Creek, Fergus County, Montana. Casino Creek is a tributary of Big Spring Creek, in the Judith River watershed. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (DEQ). Study sites lie within the Montana Valleys and Foothill Prairies ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is " ...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics specific to that ecoregion, which has been shown to be sensitive to impairment, related to habitat assessment parameters and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

## METHODS

Aquatic invertebrates were sampled at two sites by Montana DEQ personnel on August 8, 2000. Sample identifications are given, sites are described, and locations indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998) for streams with glide/pool prevalence.

**Table 1.** Sampling sites. Two sites on Casino Creek. August, 2000.

| Sample identifier | Site description | Site location |
|---|---|---|
| C 1 upstream | Headwaters-downstream of Castle Butte Road | 46° 57' 21" N 109° 26' 27"W |
| C 2 downstream | Upstream from reservoir | 47° 01' 29" N 109° 26' 15"W |

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses. In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of

predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in the Casino Creek drainage. They have been demonstrated to be more variable with anthropogenic impairment than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are

considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

**6. Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

**Table 2.** Metrics and scoring criteria for bioassessment of streams of the Montana Valleys and Foothill Prairies ecoregion (Bollman 1998).

| | *score* | | | |
|---|---|---|---|---|
| *metric* | **3** | **2** | **1** | **0** |
| **Ephemeroptera taxa richness** | > 5 | 5 - 4 | 3 - 2 | < 2 |
| **Plecoptera taxa richness** | > 3 | 3 - 2 | 1 | 0 |
| **Trichoptera taxa richness** | > 4 | 4 - 3 | 2 | < 2 |
| **Sensitive taxa richness** | > 3 | 3 - 2 | 1 | 0 |
| **Percent filterers** | 0 – 5 | 5.01 - 10 | 10.01 - 25 | > 25 |
| **Percent tolerant taxa** | 0 – 5 | 5.01 - 10 | 10.01 - 35 | > 35 |

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3a.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for

inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

| **Table 3a.** Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997) | |
|---|---|
| % Comparability to reference | Use support |
| >75 | Full support--standards not violated |
| 25-75 | Partial support--moderate impairment--standards violated |
| <25 | Non-support--severe impairment--standards violated |

| **Table 3b.** Criteria for the assignment of impairment classifications (Plafkin et al. 1989) | |
|---|---|
| % Comparability to reference | Classification |
| > 83 | nonimpaired |
| 54-79 | slightly impaired |
| 21-50 | moderately impaired |
| <17 | severely impaired |

## RESULTS

### *Habitat assessment*

Figure 1 compares habitat assessment results for the two sites in this study. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

**Figure 1.** Total habitat assessment scores, expressed as percent of maximum, for two sites on Casino Creek, August, 2000.

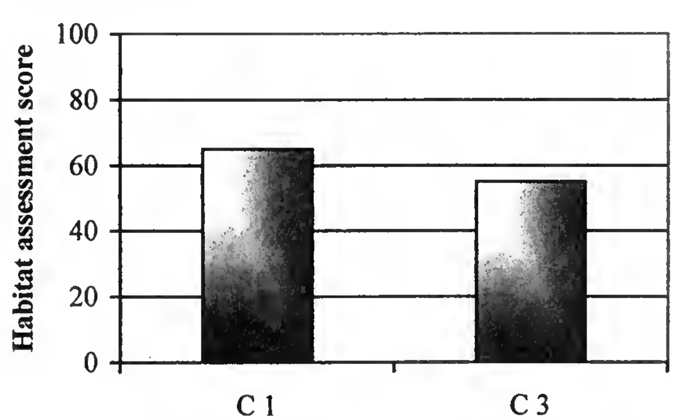


**Table 2.** Stream and riparian habitat assessment, glide/pool prevalence: Casino Creek, August 2000.

| Maximum possible score | Location: | C 1 | C 2 |
|---|---|---|---|
| | Parameter | | |
| 20 | Bottom substrate, cover | 11 | 7 |
| 20 | Pool substrate character | 16 | 10 |
| 20 | Pool variability | not scored | 7 |
| 20 | Channel alteration | 11 | 13 |
| 20 | Sediment deposition | 13 | 9 |
| 20 | Channel sinuosity | 10 | 12 |
| 20 | Channel flow status | 6 | 11 |
| 10 / 10 | Bank vegetation protection (left/right) | 9 / 9 | 8 / 8 |
| 10 / 10 | Bank stability (left/right) | 8 / 8 | 6 / 6 |
| 10 / 10 | Riparian vegetation zone width (left/right) | 8 / 8 | 6 / 6 |
| | TOTAL: | 117 | 109 |
| PERCENT OF MAXIMUM: | | 65 | 55 |
| CONDITION[1] | | SUB-OPTIMAL | SUB-OPTIMAL |

[1]Optimal >81%, Sub-Optimal 75-56%, Marginal 49-29%, Poor <23%. (Plafkin et al. 1989).

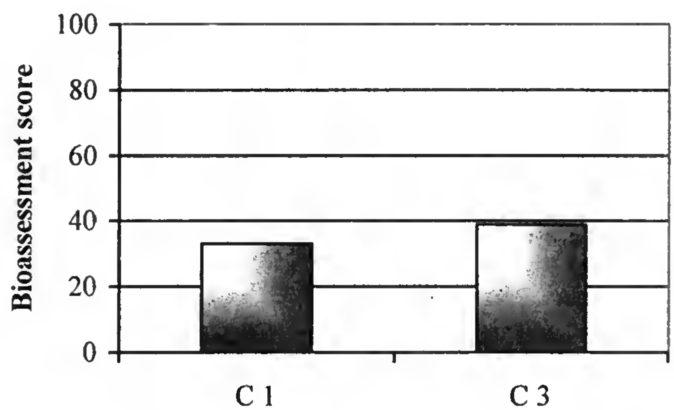
Marginal flow conditions were reported at the upstream site (C 1) on Casino Creek. Otherwise, instream conditions appeared to be sub-optimal, with predominantly sandy substrates noted, and only moderate accumulations of deposited sediment. Streambanks were perceived to be generally stable, and the riparian zone was reported to be only minimally impaired by human activities.

At the downstream site (C 2), flow conditions were reported to be somewhat better than at site C 1. Instream habitat, however, generally was perceived to be marginal, with monotonous substrate and a lack of deep pools. In addition, major deposition of fine sediments were noted. Bank stability was judged sub-optimal, and only minimal impacts to the riparian zone were noted.

*Bioassessment*

Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix. Figure 2 compares the total bioassessment scores calculated for macroinvertebrate communities collected at each of the two sites. Breakdown of scores for each metric calculated from Casino Creek macroinvertebrate samples is presented in Table 5.

**Figure 2.** Total bioassessment scores, expressed as percent of maximum, for two sites on Casino Creek, August 2000.




Moderate impairment of biotic health and partial support of designated uses was indicated for both sites on Casino Creek, based on this analysis of the benthic invertebrate assemblage. No Plecoptera taxa were collected at either site, and sensitive taxa were absent in samples as well. There were fewer Ephemeroptera taxa than expected for a foothill stream. The upstream site (C 1) supported fewer Trichoptera taxa than expected. The proportion of generally tolerant taxa was higher than expected at both sites.

*Aquatic invertebrate communities*

The taxonomic composition of the benthic assemblage collected at the upstream site (C 1) suggests moderate to severe impairment of water quality, by nutrient and/or organic pollution, warm water temperatures, or both. Effects of other pollutants, including metals cannot be excluded. Fifty-four percent of the organisms present in the sample were non-insect taxa, notably, physid snails, tubificid worms, and fingernail clams. No sensitive taxa or cold-stenotherms were present in the sample, and overall taxa richness is lower than expected. The biotic index score calculated for this assemblage was very high (7.38). Only two mayfly taxa were collected, including the ubiquitous and quite tolerant *Baetis tricaudatus*, and neither mayfly was present in abundance. The absence of stoneflies from the sample adds strength to the hypothesis of water quality impairment at site C 1. Low flow conditions, noted by the field observer, may have contributed to warm water temperatures and/or pollution effects. The presence of five

**Table 5.** Metric values and bioassessments for Casino Creek, August 2000.

| | Sites | |
|---|---|---|
| | **C 1 (upstream)** | **C 2 (downstream)** |
| **Metric** | | |
| Ephemeroptera richness | 2 | 1 |
| Plecoptera richness | 0 | 0 |
| Trichoptera richness | 1 | 7 |
| Sensitive taxa richness | 0 | 0 |
| Percent tolerant taxa | 33 | 25 |
| Percent filter-feeders | 3 | 4 |
| | **Metric scores** | |
| Ephemeroptera richness | 2 | 0 |
| Plecoptera richness | 0 | 0 |
| Trichoptera richness | 0 | 3 |
| Sensitive taxa richness | 0 | 0 |
| Percent tolerant taxa | 1 | 1 |
| Percent filter-feeders | 3 | 3 |
| Total score (maximum = 18) | 6 | 7 |
| Percent of maximum | 33 | 39 |
| Use support* | **PARTIAL** | **PARTIAL** |
| Impairment classification[1] | **MOD** | **MOD** |

1. Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
*Use support designations: See Table 3a.

long-lived taxa suggests that complete dewatering or other catastrophic events do not chronically interrupt long life cycles in this reach of Casino Creek.

Habitat degradation by human activities is not strongly reflected in the habitat assessment performed at the time of sampling, however, its contribution cannot be evaluated easily since the influence of water quality impairment appears so strong. Only three "clinger" taxa (*Dubiraphia* sp., *Optioservus* sp., and *Simulium* sp.) were present in the sample, along with only four individuals of a single caddis fly taxon (*Lepidostoma* sp.). While this would ordinarily strongly suggest that fine sediment deposition compromised benthic habitats, the effect of water quality disturbances could also explain these findings. The fact that the three "clinger" taxa present at the site are all quite tolerant of degraded water quality supports this notion.

At the downstream site (C 2), sampling yielded a considerably richer benthic assemblage than did the upstream site; thirty-three taxa were collected. However, a high biotic index value (7.00), the paucity of mayfly taxa (only *Baetis tricaudatus* was present), an abundance of non-insect taxa (34% of the assemblage) and midges (43% of the assemblage) suggest that water quality impairment persists at this site. No stonefly was present, nor any cold-stenotherms. Tubificid worms and physid snails, both of which are tolerant to both warm water temperatures as well as organic and/or nutrient pollution,

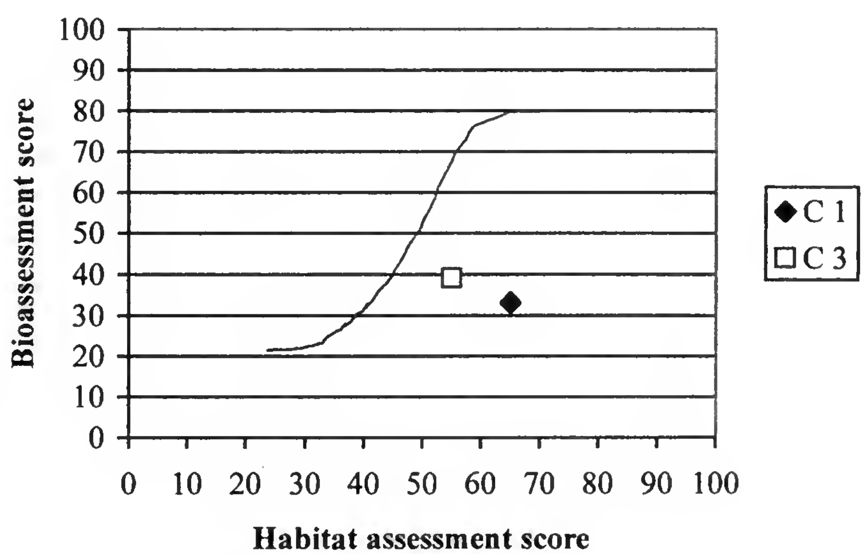
are among the dominant taxa collected here. Together, they comprise nearly 30% of the sampled assemblage.

Seven caddis fly taxa, including the warm-water selective *Helicopsyche borealis,* were present, and 8 "clinger" taxa, giving a clear indication that benthic habitats were not significantly impacted by fine sediment deposition. The presence of the midge *Odontomesa* sp. strongly suggests that sandy substrates are prevalent. Other than this evidence pertaining to the condition of the benthic substrate, indications of the effects of habitat degradation on the benthic assemblage seem to be obscured by the effects of water quality impairment.

## CONCLUSIONS

- Water quality impairment appears to limit the biotic health of both sites in Casino Creek. Impairment appears to be due to warm water temperatures as well as nutrient and/or organic pollution.
- The relationship between habitat assessment scores and bioassessment scores is illustrated in Figure 3. Points representing the sites lie below a line describing the expected relationship between habitat and biotic health when water quality is unimpaired. This suggests that bioassessment scores are somewhat lower than would be expected if impairment was due to habitat degradation alone, and suggests that water quality impairment, perhaps by warm water temperatures and/or pollution, was the predominant factor limiting biotic health in these reaches of Casino Creek. Low flow conditions may have influenced water temperatures.

**Figure 3.** Total bioassessment scores plotted against habitat assessment scores for two sites on Casino Creek, August 2000. The red line describes the hypothetical relationship expected when water quality is good and biotic health is determined predominantly by habitat quality (Barbour and Stribling 1991).



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## APPENDIX

**Taxonomic data and summaries**

**Casino Creek**

**August 8, 2000**

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Casino Creek**
**Site ID: C 1 8/8/00**

Approx. percent of sample used: 20

| **Taxon** | **Quantity** | **Percent** | **HBI** | **FFG** |
|---|---|---|---|---|
| Tubificidae - immature | 49 | 16.23 | 9 | CG |
| *Helobdella stagnalis* | 9 | 2.98 | 6 | PR |
| Sphaeriidae | 42 | 13.91 | 8 | CG |
| *Fossaria* sp. | 3 | 0.99 | 6 | CG |
| Physidae | 62 | 20.53 | 8 | CG |
| Planorbidae | 1 | 0.33 | 6 | SC |
| **Total Misc. Taxa** | **166** | **54.97** | | |
| *Aeshna* sp. | 3 | 0.99 | 5 | PR |
| **Total Odonata** | **3** | **0.99** | | |
| *Baetis tricaudatus* | 5 | 1.66 | 6 | CG |
| *Paraleptophlebia* sp. | 1 | 0.33 | 4 | CG |
| **Total Ephemeroptera** | **6** | **1.99** | | |
| Corixidae - immature | 26 | 8.61 | 8 | UN |
| *Sigara* sp. | 29 | 9.60 | 8 | PH |
| **Total Hemiptera** | **55** | **18.21** | | |
| *Lepidostoma* sp.-turret case larvae | 4 | 1.32 | 2 | SH |
| **Total Trichoptera** | **4** | **1.32** | | |
| *Nebrioporus* sp. | 1 | 0.33 | 5 | PR |
| *Dubiraphia* sp. | 13 | 4.30 | 6 | CG |
| *Optioservus* sp. | 5 | 1.66 | 4 | SC |
| *Brychius* sp. | 3 | 0.99 | 5 | MH |
| **Total Coleoptera** | **22** | **7.28** | | |
| Ceratopogoninae | 4 | 1.32 | 6 | PR |
| *Dixa* sp. | 3 | 0.99 | 2 | CG |
| Ephydridae | 3 | 0.99 | 6 | CG |
| *Simulium* sp. | 9 | 2.98 | 6 | CF |
| **Total Diptera** | **19** | **6.29** | | |
| *Apsectrotanypus* sp. | 20 | 6.62 | 6 | PR |
| *Brillia* sp. | 4 | 1.32 | 5 | SH |
| *Procladius* sp. | 3 | 0.99 | 9 | CG |
| **Total Chironomidae** | **27** | **8.94** | | |
| **Grand Total** | **302** | **100.00** | | |

**Aquatic Invertebrate Summary Data**

**Site Name: Casino Creek** — **Site ID: C 1 8/8/00**

| | |
|---|---|
| TOTAL ABUNDANCE | 303 |
| Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance | 10 |
| TOTAL NUMBER OF TAXA | 24 |
| Number EPT taxa | 3 |

TAXONOMIC GROUP COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Misc. Taxa | 6 | 166 | 54.79 |
| Odonata | 2 | 4 | 1.32 |
| Ephemeroptera | 2 | 6 | 1.98 |
| Plecoptera | 0 | 0 | 0.00 |
| Hemiptera | 2 | 55 | 18.15 |
| Megaloptera | 0 | 0 | 0.00 |
| Trichoptera | 1 | 4 | 1.32 |
| Lepidoptera | 0 | 0 | 0.00 |
| Coleoptera | 4 | 22 | 7.26 |
| Diptera | 4 | 19 | 6.27 |
| Chironomidae | 3 | 27 | 8.91 |

RATIOS OF TAX GROUP ABUNDANCES

| | |
|---|---|
| EPT/Chironomidae | 0.37 |

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Predator | 6 | 38 | 12.54 |
| Parasite | 0 | 0 | 0.00 |
| Collector-gatherer | 10 | 184 | 60.73 |
| Collector-filterer | 1 | 9 | 2.97 |
| Macrophyte-herbivore | 1 | 3 | 0.99 |
| Piercer-herbivore | 1 | 29 | 9.57 |
| Scraper | 2 | 6 | 1.98 |
| Shredder | 2 | 8 | 2.64 |
| Xylophage | 0 | 0 | 0.00 |
| Omnivore | 0 | 0 | 0.00 |
| Unknown | 1 | 26 | 8.58 |

RATIOS OF FFG ABUNDANCES

| | |
|---|---|
| Scraper/Collector-filterer | 0.67 |
| Scraper/(Scraper + C.filterer) | 0.40 |
| Shredder/Total organisms | 0.01 |

CONTRIBUTION OF DOMINANT TAXA

| TAXON | ABUNDANCE | PERCENT |
|---|---|---|
| Physidae | 62 | 20.46 |
| Tubificidae - immature | 49 | 16.17 |
| Sphaeriidae | 42 | 13.86 |
| *Sigara* sp. | 29 | 9.57 |
| Corixidae - immature | 26 | 8.58 |
| SUBTOTAL 5 DOMINANTS | 208 | 68.65 |
| *Apsectrotanypus* sp. | 20 | 6.60 |
| *Dubiraphia* sp. | 13 | 4.29 |
| *Helobdella stagnalis* | 9 | 2.97 |
| *Simulium* sp. | 9 | 2.97 |
| *Baetis tricaudatus* | 5 | 1.65 |
| TOTAL DOMINANTS | 264 | 87.13 |

SAPROBIC INDICES

| | |
|---|---|
| Hilsenhoff Biotic Index | 7.38 |

DIVERSITY MEASURES

| | |
|---|---|
| Shannon H (loge) | 2.15 |
| Shannon H (log2) | 3.10 |
| Evenness | 0.68 |
| Simpson D | 0.10 |

COMMUNITY VOLTINISM ANALYSIS

| TYPE | ABUNDANCE | PERCENT |
|---|---|---|
| Multivoltine | 24 | 7.92 |
| Univoltine | 232 | 76.57 |
| Semivoltine | 47 | 15.51 |

| | #TAXA | ABUNDANCE | PERCENT |
|---|---|---|---|
| Tolerant | 10 | 99 | 32.67 |
| Intolerant | 0 | 0 | 0.00 |
| Clinger | 3 | 27 | 8.91 |

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Casino Creek**

**Site ID: C 2**

Approx. percent of sample used: 33

| Taxon | Quantity | Percent | HBI | FFG |
|---|---|---|---|---|
| *Nais variabilis* | 6 | 1.89 | 8 | CG |
| Tubificidae - immature | 65 | 20.44 | 9 | CG |
| *Glossiphonia complanata* | 1 | 0.31 | 6 | PR |
| *Helobdella stagnalis* | 4 | 1.26 | 6 | PR |
| Sphaeriidae | 2 | 0.63 | 8 | CG |
| *Ferrissia rivularis* | 3 | 0.94 | 6 | SC |
| Physidae | 26 | 8.18 | 8 | CG |
| **Total Misc. Taxa** | 107 | **33.65** | | |
| *Baetis tricaudatus* | 13 | 4.09 | 6 | CG |
| **Total Ephemeroptera** | **13** | **4.09** | | |
| *Sigara* sp. | 2 | 0.63 | 8 | PH |
| **Total Hemiptera** | **2** | **0.63** | | |
| Arctopsychinae - early instars | 1 | 0.31 | 2 | PR |
| *Helicopsyche borealis* | 8 | 2.52 | 7 | SC |
| *Hydropsyche* sp. | 14 | 4.40 | 4 | CF |
| *Hydroptila* sp. | 3 | 0.94 | 6 | PH |
| *Lepidostoma* sp.-turret case larvae | 1 | 0.31 | 2 | SH |
| *Onocosmoecus unicolor* | 1 | 0.31 | 1 | OM |
| *Polycentropus* sp. | 1 | 0.31 | 6 | PR |
| **Total Trichoptera** | **29** | **9.12** | | |
| *Dubiraphia* sp. | 22 | 6.92 | 6 | CG |
| *Lara avara* | 1 | 0.31 | 4 | SH |
| **Total Coleoptera** | **23** | **7.23** | | |
| *Dixa* sp. | 1 | 0.31 | 2 | CG |
| Tabanidae | 3 | 0.94 | 8 | PR |
| *Dicranota* sp. | 1 | 0.31 | 3 | PR |
| *Pedicia* sp. | 1 | 0.31 | 6 | PR |
| *Tipula* sp. | 1 | 0.31 | 4 | OM |
| **Total Diptera** | **7** | **2.20** | | |
| *Brillia* sp. | 2 | 0.63 | 5 | SH |
| *Corynoneura* sp. | 2 | 0.63 | 7 | CG |
| Cricotopus Bicinctus Gr. | 108 | 33.96 | 7 | CG |
| *Cryptochironomus* sp. | 2 | 0.63 | 8 | PR |
| *Cryptotendipes* sp. | 1 | 0.31 | 6 | UN |
| *Odontomesa* sp. | 9 | 2.83 | 4 | CG |
| *Pagastia* sp. | 1 | 0.31 | 1 | CG |
| *Paratanytarsus* sp. | 9 | 2.83 | 6 | UN |
| *Thienemanniella* sp. | 1 | 0.31 | 6 | CG |
| Thienemannimyia Gr. | 2 | 0.63 | 6 | PR |
| **Total Chironomidae** | **137** | **43.08** | | |
| **Grand Total** | **318** | **100.00** | | |

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Casino Creek**
**Site ID: C 2**

Approx. percent of sample used: 33

| Taxon | Quantity | Percent | HBI | FFG |
|---|---|---|---|---|
| *Nais variabilis* | 6 | 1.89 | 8 | CG |
| Tubificidae - immature | 65 | 20.44 | 9 | CG |
| *Glossiphonia complanata* | 1 | 0.31 | 6 | PR |
| *Helobdella stagnalis* | 4 | 1.26 | 6 | PR |
| Sphaeriidae | 2 | 0.63 | 8 | CG |
| *Ferrissia rivularis* | 3 | 0.94 | 6 | SC |
| Physidae | 26 | 8.18 | 8 | CG |
| **Total Misc. Taxa** | 107 | **33.65** | | |
| *Baetis tricaudatus* | 13 | 4.09 | 6 | CG |
| **Total Ephemeroptera** | **13** | **4.09** | | |
| *Sigara* sp. | 2 | 0.63 | 8 | PH |
| **Total Hemiptera** | **2** | **0.63** | | |
| Arctopsychinae - early instars | 1 | 0.31 | 2 | PR |
| *Helicopsyche borealis* | 8 | 2.52 | 7 | SC |
| *Hydropsyche* sp. | 14 | 4.40 | 4 | CF |
| *Hydroptila* sp. | 3 | 0.94 | 6 | PH |
| *Lepidostoma* sp.-turret case larvae | 1 | 0.31 | 2 | SH |
| *Onocosmoecus unicolor* | 1 | 0.31 | 1 | OM |
| *Polycentropus* sp. | 1 | 0.31 | 6 | PR |
| **Total Trichoptera** | **29** | **9.12** | | |
| *Dubiraphia* sp. | 22 | 6.92 | 6 | CG |
| *Lara avara* | 1 | 0.31 | 4 | SH |
| **Total Coleoptera** | **23** | **7.23** | | |
| *Dixa* sp. | 1 | 0.31 | 2 | CG |
| Tabanidae | 3 | 0.94 | 8 | PR |
| *Dicranota* sp. | 1 | 0.31 | 3 | PR |
| *Pedicia* sp. | 1 | 0.31 | 6 | PR |
| *Tipula* sp. | 1 | 0.31 | 4 | OM |
| **Total Diptera** | **7** | **2.20** | | |
| *Brillia* sp. | 2 | 0.63 | 5 | SH |
| *Corynoneura* sp. | 2 | 0.63 | 7 | CG |
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| *Pagastia* sp. | 1 | 0.31 | 1 | CG |
| *Paratanytarsus* sp. | 9 | 2.83 | 6 | UN |
| *Thienemanniella* sp. | 1 | 0.31 | 6 | CG |
| Thienemannimyia Gr. | 2 | 0.63 | 6 | PR |
| **Total Chironomidae** | **137** | **43.08** | | |
| **Grand Total** | **318** | **100.00** | | |